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(71) Applicant(s)
Samsung Electronics Co Limited
(Incorporated in the Republic of Korea)
416 Maetan-dong, Paldal-gu, Suwon-city,
Kyungki-do, Republic of Korea

(72) Inventor(s)
Young-Soo Park
Yun-Hee Lee
Sang-Hwan Park

(74) Agent and/or Address for Service
Dibb Lupton Alsop
Fountain Precinct, Balm Green, SHEFFIELD, S1 1RZ,
United Kingdom

(54) Abstract Title
Method of detecting the presence of a mobile phone in a restricted area

(57) The detection apparatus 100 comprises a signal generating unit 300 for generating a simulated base station signal, in particular a pilot signal, which is transmitted within the restricted area. Any mobile telephone in an idle state present in the restricted area will receive the simulated base station signal and transmit a response, in this case a registration request, which is detected at the detecting unit 400 of the detection apparatus. An alarm 500 is generated when such a response is received. A user can be informed that the mobile telephone is turned on. The method may prevent public inconvenience or interference with electronic equipment by restricting mobile telephone in a building or aircraft.

FIG. 3

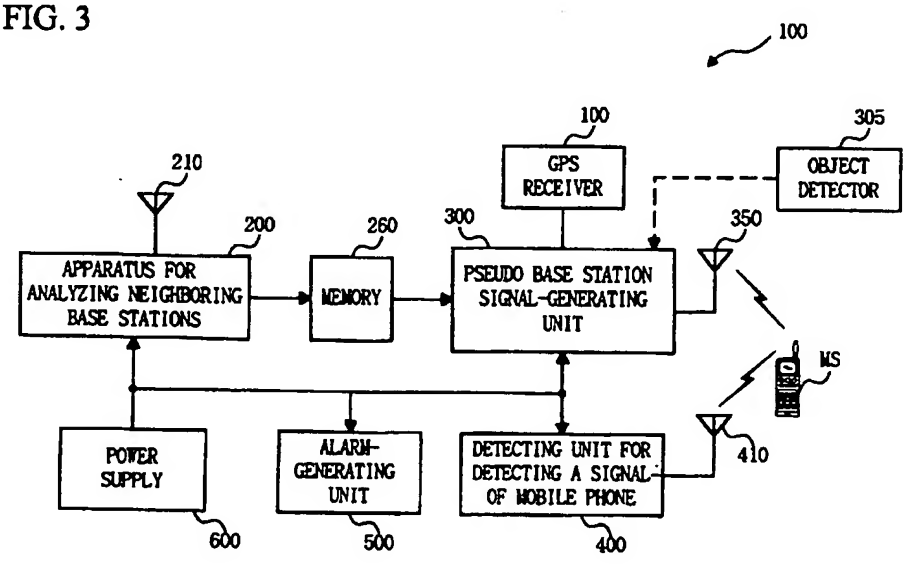

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FIG. 1

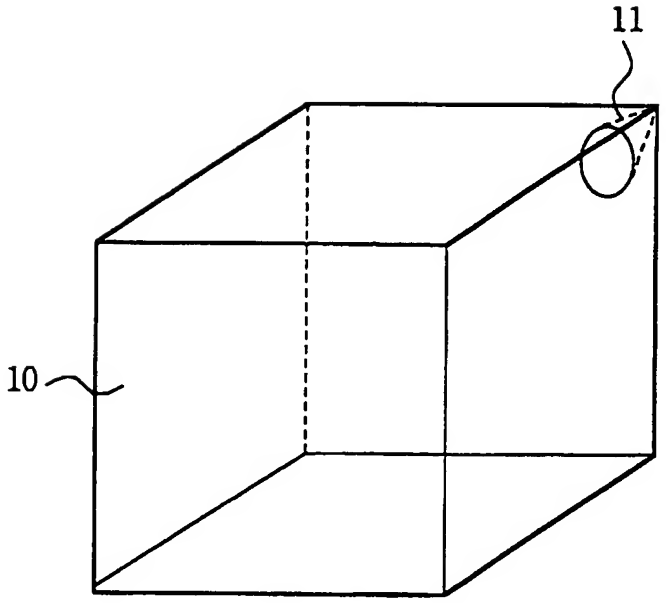


FIG.2

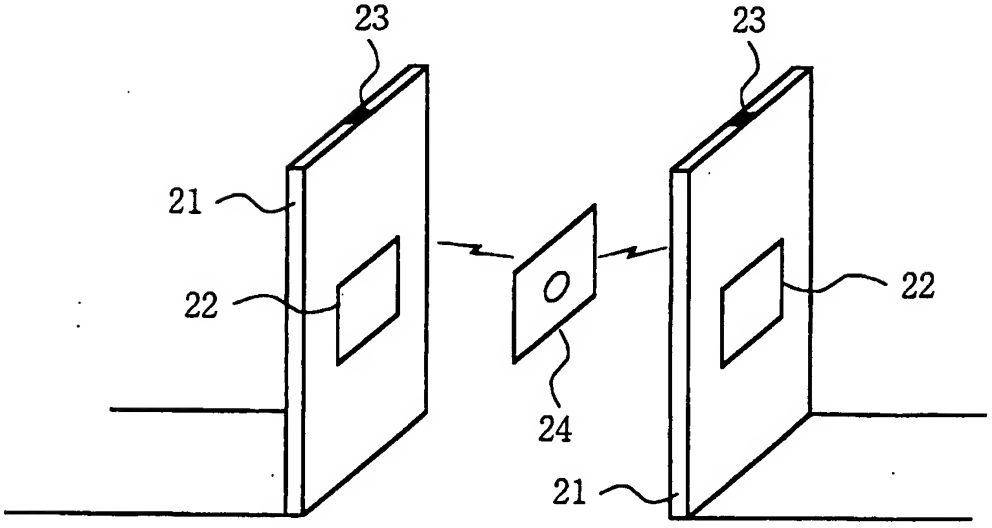


FIG. 3

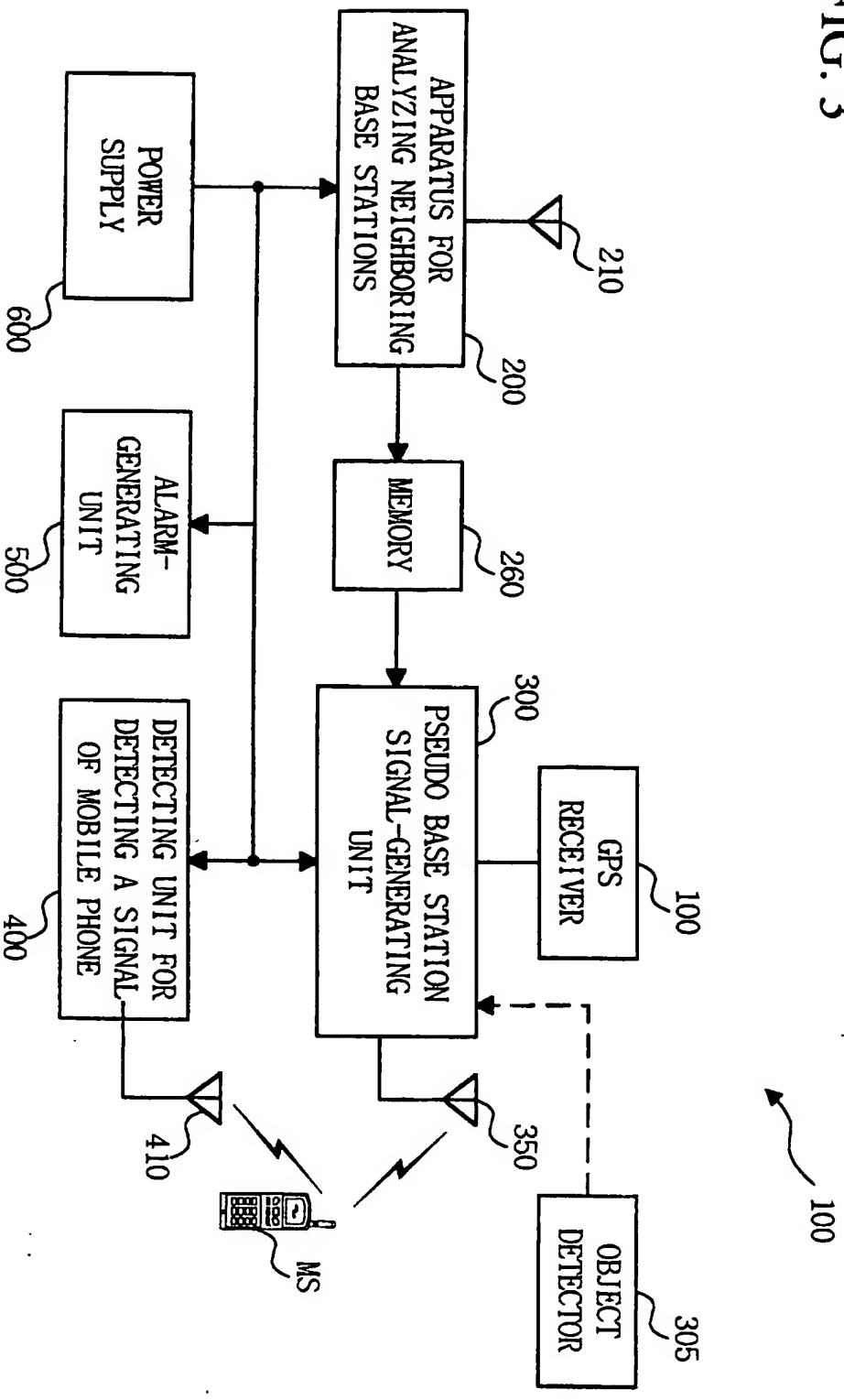

APPARATUS FOR ANALYZING NEIGHBORING BASE STATIONS
200
210
POWER SUPPLY
600
MEMORY
260
ALARM-GENERATING UNIT
500
PSEUDO BASE STATION SIGNAL-GENERATING UNIT
300
GPS RECEIVER
100
DETECTING UNIT FOR DETECTING A SIGNAL OF MOBILE PHONE
400
410
350
MS
OBJECT DETECTOR
305
100

FIG. 4

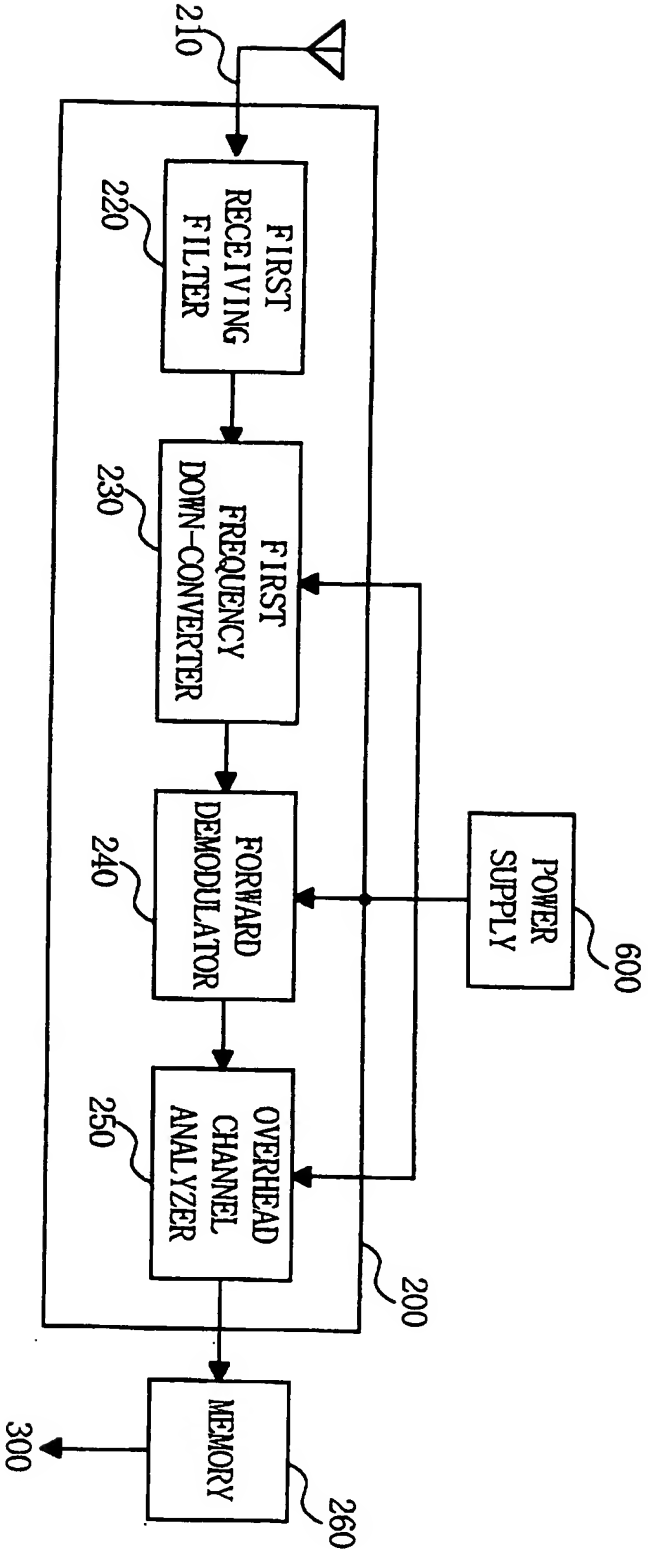

210
FIRST RECEIVING FILTER
220
FIRST FREQUENCY DOWN-CONVERTER
230
FORWARD DEMODULATOR
240
OVERHEAD CHANNEL ANALYZER
250
MEMORY
260
POWER SUPPLY
600
200
300

FIG. 5

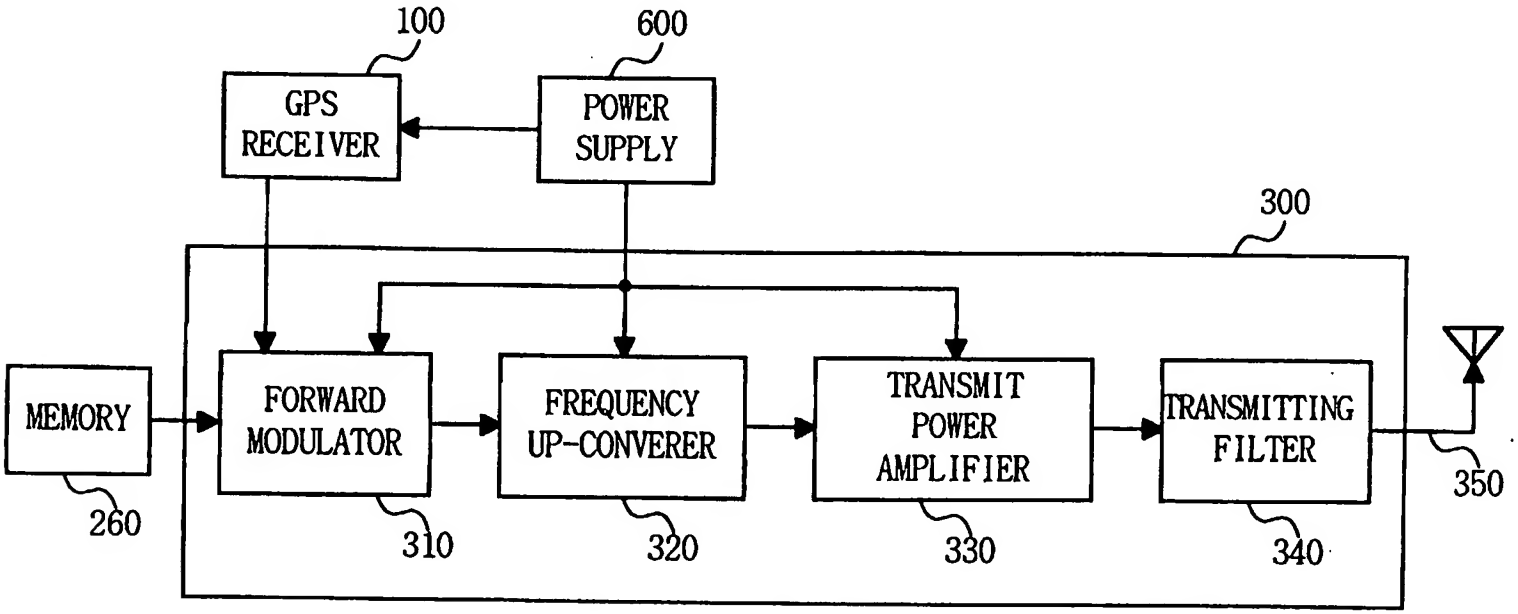

100
600
GPS RECEIVER
POWER SUPPLY
300
MEMORY
FORWARD MODULATOR
FREQUENCY UP-CONVERER
TRANSMIT POWER AMPLIFIER
TRANSMITTING FILTER
260
310
320
330
340
350

FIG. 6

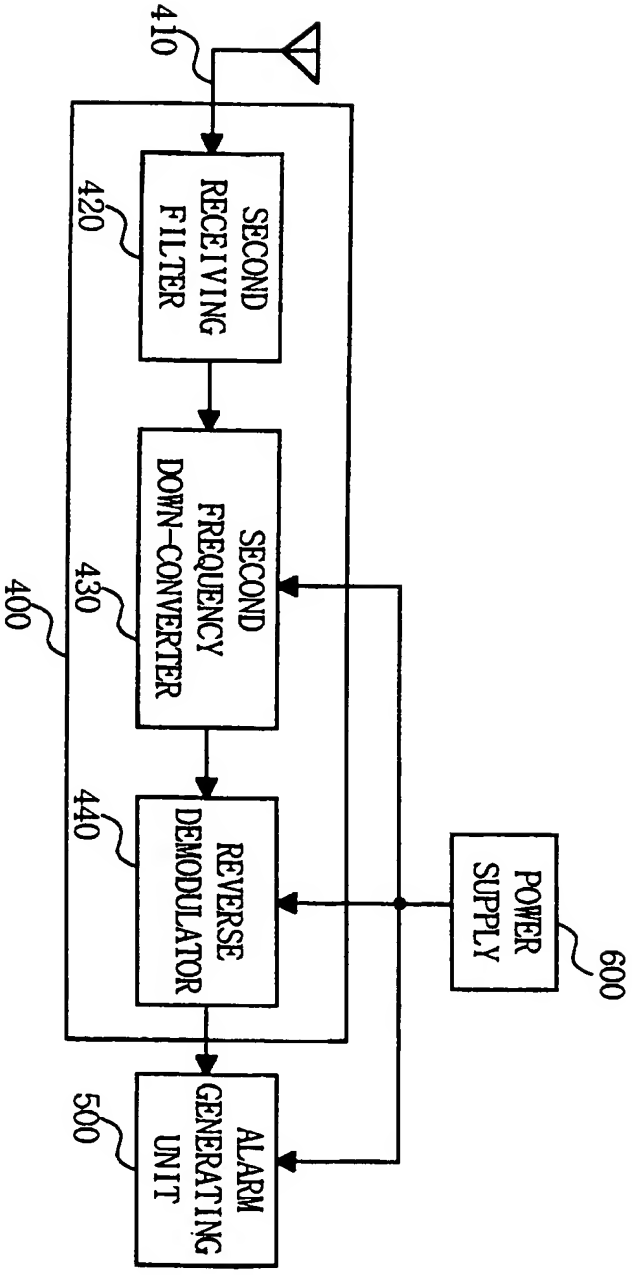

410
SECOND RECEIVING FILTER
420
SECOND FREQUENCY DOWN-CONVERTER
430
400
REVERSE DEMODULATOR
440
POWER SUPPLY
600
ALARM GENERATING UNIT
500

FIG. 7

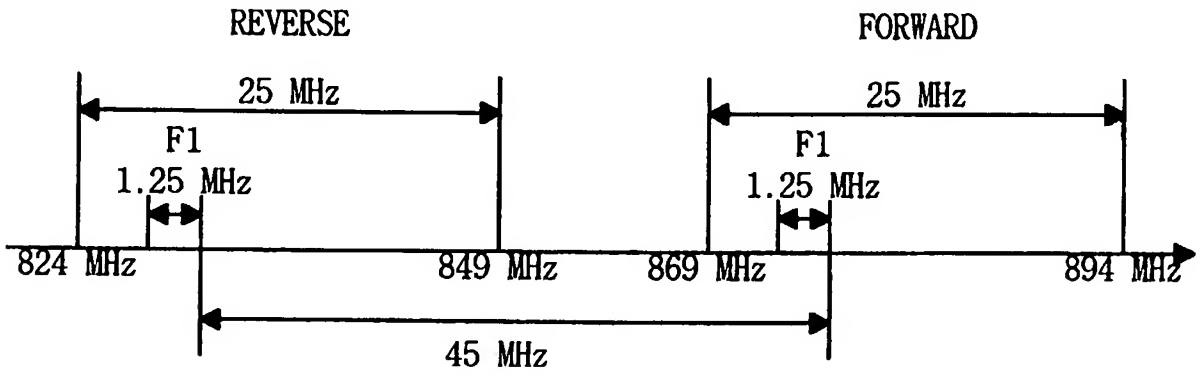

REVERSE
FORWARD
25 MHz
25 MHz
F1
1.25 MHz
F1
1.25 MHz
824 MHz
849 MHz
869 MHz
894 MHz
45 MHz

FIG. 8

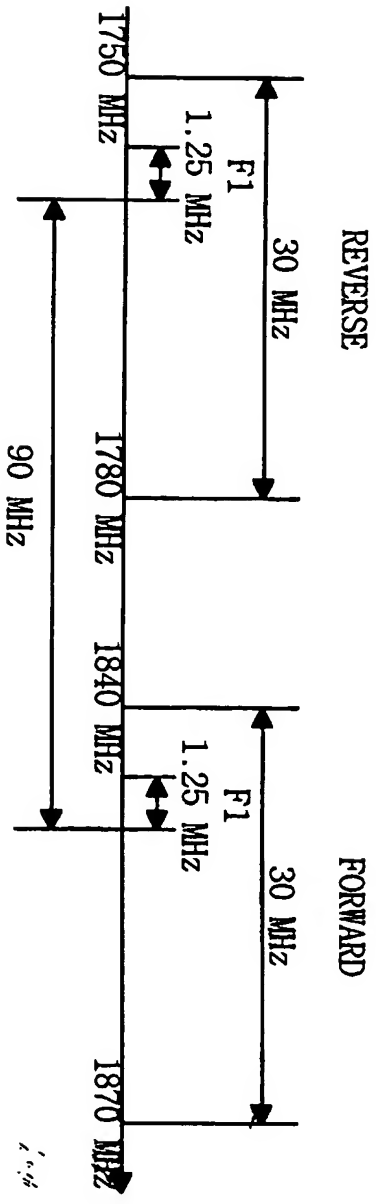

1750 MHz
F1
1.25 MHz
30 MHz
REVERSE
90 MHz
1780 MHz
1840 MHz
F1
1.25 MHz
30 MHz
FORWARD
1870 MHz

FIG. 9

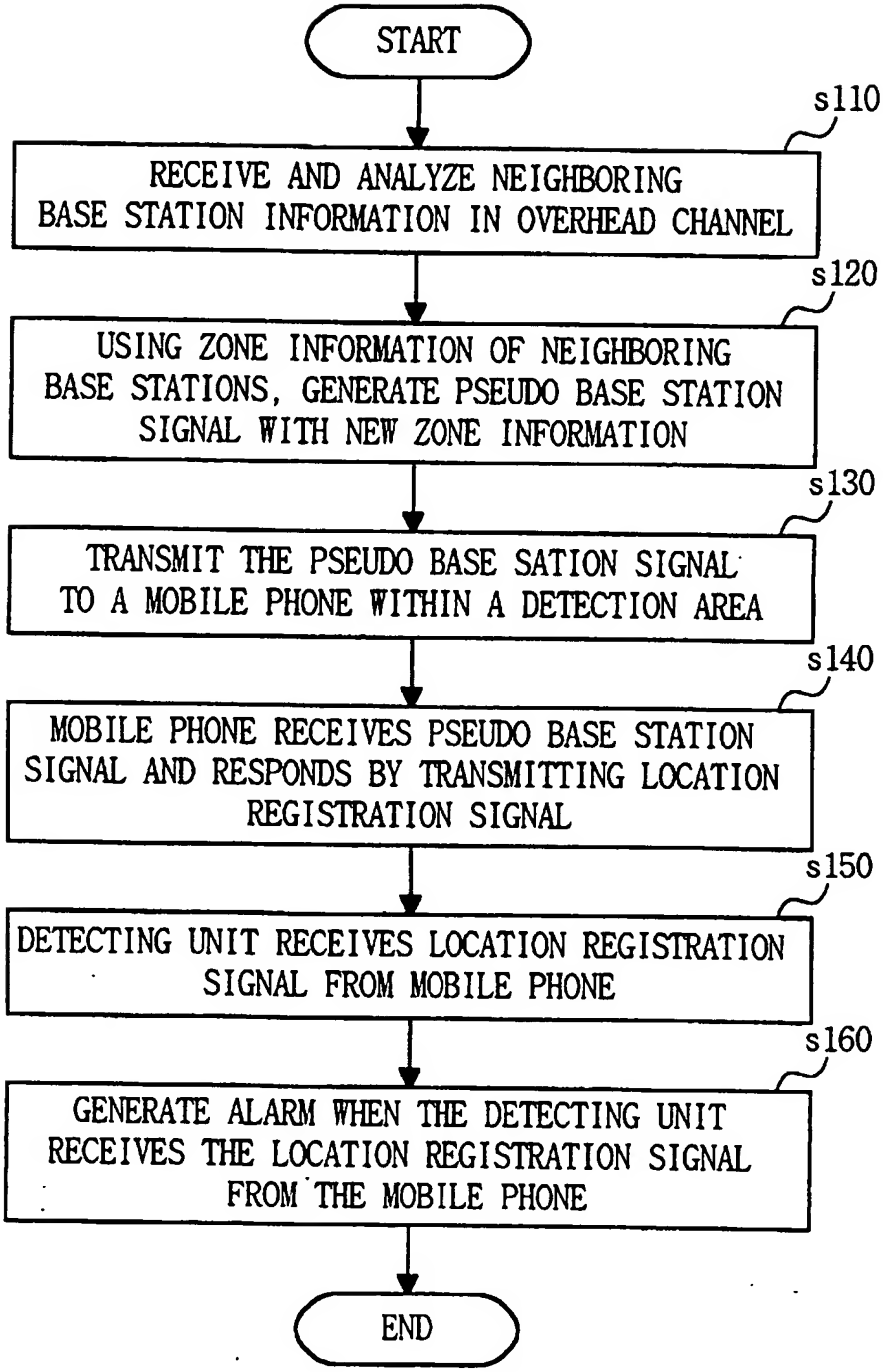
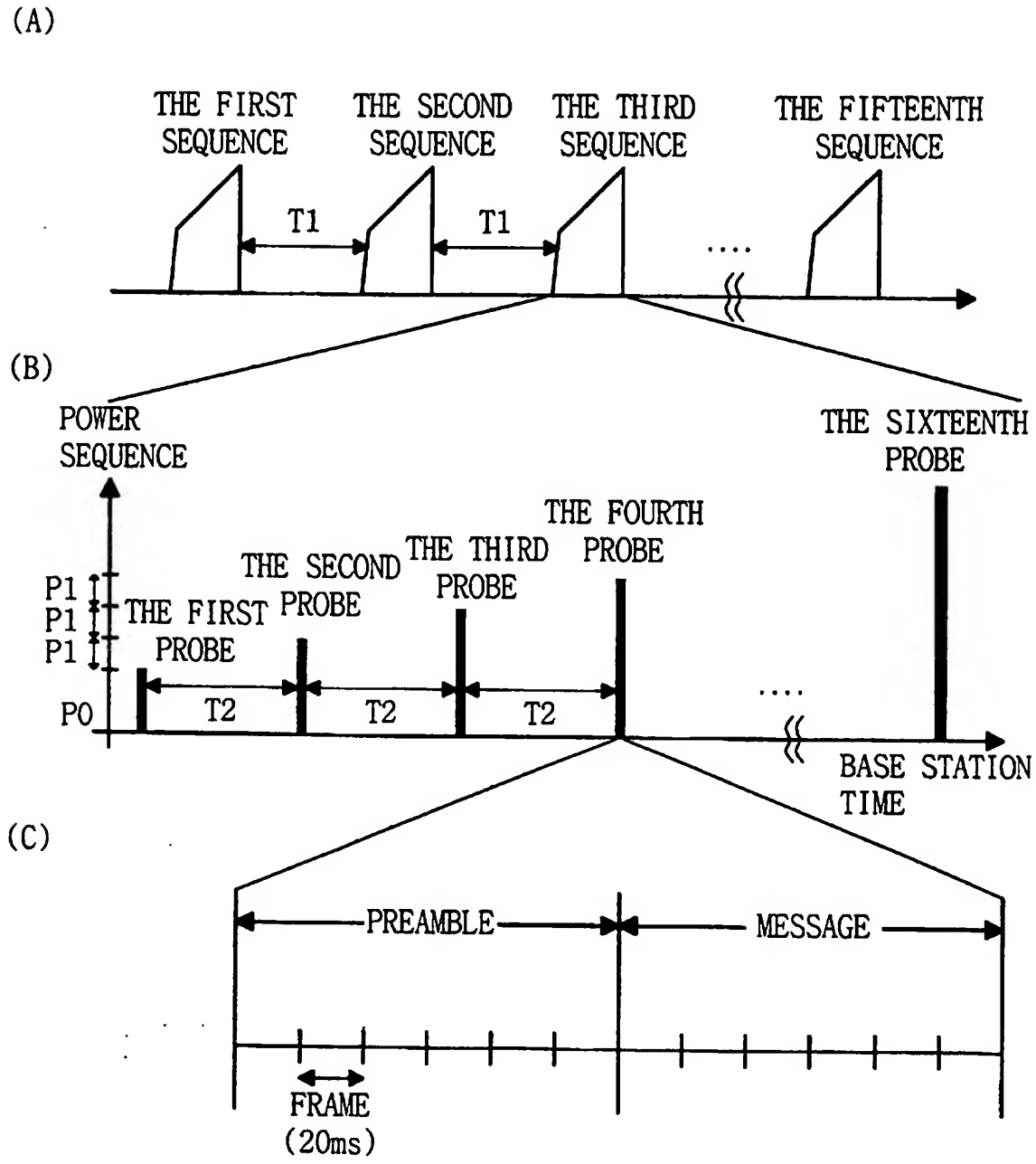

START
s110
RECEIVE AND ANALYZE NEIGHBORING BASE STATION INFORMATION IN OVERHEAD CHANNEL
s120
USING ZONE INFORMATION OF NEIGHBORING BASE STATIONS, GENERATE PSEUDO BASE STATION SIGNAL WITH NEW ZONE INFORMATION
s130
TRANSMIT THE PSEUDO BASE SATION SIGNAL TO A MOBILE PHONE WITHIN A DETECTION AREA
s140
MOBILE PHONE RECEIVES PSEUDO BASE STATION SIGNAL AND RESPONDS BY TRANSMITTING LOCATION REGISTRATION SIGNAL
s150
DETECTING UNIT RECEIVES LOCATION REGISTRATION SIGNAL FROM MOBILE PHONE
s160
GENERATE ALARM WHEN THE DETECTING UNIT RECEIVES THE LOCATION REGISTRATION SIGNAL FROM THE MOBILE PHONE
END

FIG. 10


(A)
THE FIRST SEQUENCE
THE SECOND SEQUENCE
THE THIRD SEQUENCE
THE FIFTEENTH SEQUENCE
T1
T1
....
(B)
POWER SEQUENCE
THE SIXTEENTH PROBE
THE FOURTH PROBE
THE THIRD PROBE
THE SECOND PROBE
THE FIRST PROBE
P1
P1
P1
P0
T2
T2
T2
....
BASE STATION TIME
(C)
PREAMBLE
MESSAGE
FRAME
(20ms)

APPARATUS AND METHOD FOR DETECTING A MOBILE TELEPHONE

Background of the Invention

The present invention relates to a method and apparatus for detecting a mobile telephone in an idle state, and in particular, for generating an alarm when a mobile telephone in idle state enters an area where the usage of mobile telephones is prohibited.

A typical cellular telephone system includes a plurality of base stations, each of which services a geographical cell of a small-scale area. Coverage over a wide area is provided by a multiplicity of such cells. The base stations are centrally controlled by a mobile switching centre (MSC) so that a mobile telephone subscriber can maintain communication when moving between cells.

Cellular telephone systems are advantageous in that they provide service to mobile telephone subscribers within any cell covered by the system. However, a drawback to the cellular system is that inconvenience or danger may be caused by the use of mobile telephones in an area where such use is prohibited. For example, if a mobile telephone rings while in a concert or exhibition hall, the resulting noise is a disturbance to the performance. Further disturbance results if the user actually answers the call. Additionally, mobile telephone signal transmissions may dangerously interfere with the

operation of sensitive electronic equipment such as in a hospital or an aeroplane. Such electronic equipment can be adversely affected by traffic channel signals as well as control channel signals, such as those sent back and forth between mobile telephones and base stations during the call set-up process, or during the registration process when a mobile telephone is first turned on.

One conventional technique to restrict use of mobile telephones in a specific area is to employ an apparatus for generating an interference signal to essentially "jam" the mobile telephone and thereby prevent it from operating properly. FIG. 1 shows an embodiment illustrating a prior art apparatus for generating an interference signal for this purpose. An apparatus 11 generates an RF interference signal so as to prevent use of a mobile telephone inside a building 10. However, in general, buildings have windows or other entrances for radio waves from the exterior. As such, with the approach of FIG. 1, it is impossible to completely shut out radio frequency entering from external base stations attempting to communicate and/or send control channel signals to mobile telephones within the building. Another problem is that the RF interference signal generated by apparatus 11 may cause other electronic equipment to malfunction.

Another prior art technique for restricting mobile telephone use involves the deployment of magnetic material detectors in selected locations to detect the presence of mobile telephones, which have magnetic material therein. FIG. 2 shows an embodiment of an

apparatus for detecting magnetic substances. When a person carrying an object 24 having magnetic components enters through an entrance 21, a magnetic detector 22 established inside the entrance 21 detects the magnetic components and transmits an alarm signal to an alarm generator 23, which then sounds an alarm. A drawback to this approach is that it will detect such telephones and sound an alarm regardless of whether the telephones are in use or not.

Traditionally, in such restricted use environments, announcements are made to the public exhorting mobile telephone owners to turn off their telephones, but inevitably, some telephones remain turned on. Hence, there is a need for a system that automatically detects the presence of a mobile telephone in the idle state in public areas.

Summary of the Invention

The present invention is directed to a method and apparatus for detecting the presence of a mobile telephone. The telephone may be in an idle state, that is, a state in which the mobile telephone is powered up but not performing communication. Embodiments of the invention render it possible to detect, for example, a mobile telephone in the idle state within a specific indoor area, or upon entering an entranceway.

In an illustrative embodiment of the invention, there is provided an apparatus for detecting a mobile telephone

comprising a signal generating unit for generating a pseudo base station signal; a detecting unit adapted to detect a response signal transmitted by a mobile telephone in response to the pseudo base station signal; and an alarm generating unit for generating an alarm when said detecting unit detects said response signal.

Preferably, said pseudo base station signal includes zone information differing from zone information used in base stations in the vicinity of the apparatus. The zone information may include one or more of: pseudo-random noise (PN) code offset; zone number; a system identifier (SID); and a network identifier (NID).

The apparatus may further include circuitry for analysing signals received from neighbouring base stations, to extract neighbouring base station information therefrom. The signal generating unit may adapt the pseudo base station signal according to said neighbouring base station information.

The circuitry for analysing signals received from neighbouring base stations may comprise a first receiving antenna for receiving radio frequency (RF) signals through an overhead channel from the neighbouring base stations; a first receiving filter to filter said received signals; a first frequency down-converter to convert the filtered signal to a baseband signal; a forward demodulator to demodulate the baseband signal; and an overhead channel analyser to analyse the demodulated signal and generate said neighbouring base

station information.

The extracted neighbouring base station information may include one or more of: transmit frequency status; pilot signal strength; and pseudo-random noise (PN) code offset.

The signal-generating unit may comprise a forward modulator for generating an overhead channel signal; an up-converter for converting the overhead channel signal to an RF signal in a frequency band of a code division multiple access (CDMA) system; a transmit power amplifier for amplifying the RF signal; a transmitting filter for filtering the amplified signal; and a transmitting antenna for transmitting the filtered signal as said pseudo base station signal.

The apparatus may further comprise a global positioning system (GPS) receiver for receiving time information from a satellite and generating therefrom a system reference clock. The signal-generating unit may generate said pseudo base station signal using the system reference clock. The forward modulator may generate the overhead channel signal using the system reference clock.

The transmit power amplifier may amplify the RF signal to a power level of several milliwatts, so as to prevent interference with electronic equipment outside a specific detection area.

The transmitting antenna may transmit an overall forward

frequency band of a CDMA system. The transmitting antenna may transmit a narrow beamwidth directed towards a specific detection area.

The apparatus may transmit the pseudo base station signal in response to a signal from an object detector indicating that an object is within a specific detection area.

The detecting unit may comprise a receiving antenna for receiving radio frequency (RF) signals from a mobile telephone; a receiving filter for filtering said received RF signals; a down-converter for converting the filtered signal to a baseband signal; and a reverse demodulator for de-spreading and demodulating the baseband signal and forwarding an alarm signal to the alarm-generating unit when said response signal of the mobile telephone is detected within said demodulated signal.

A frequency separation, at a given time, between a passband of said receiving filter and a passband of a transmitting filter of said signal generating unit that filters the pseudo base station signal, may be selected from the group consisting of 45MHz and 90MHz.

The receiving filter and the transmitting filter may each have a passband of 1.25 MHz.

The signal-generating unit may comprise circuitry for generating said pseudo base station signal at frequencies, and with a protocol, of a code division

multiple access (CDMA) cellular system; and/or circuitry for generating said pseudo base station signal at frequencies, and with a protocol of, a CDMA personal communication service (PCS) system.

The detecting unit may comprise circuitry for detecting a signal that a mobile telephone transmits at frequencies, and with a protocol, of a CDMA cellular system; and/or circuitry for detecting a signal that said mobile telephone transmits at frequencies, and with a protocol, of a CDMA personal communication service (PCS) system.

The detection unit may be located in an entranceway.

The pseudo base station signal is preferably adapted to cause a mobile telephone to transmit location registration signals; and wherein the detecting unit is adapted to detect said location registration signals.

The present invention also provides a method for detecting a mobile telephone, said method comprising the steps of transmitting a pseudo base station signal within a detection area, said pseudo base station signal being adapted to cause a mobile telephone in said detection area to transmit a response signal; receiving a response signal from a mobile telephone; and generating an alarm in response to the reception of the response signal from the mobile telephone.

The pseudo base station signal preferably contains zone information differing from zone information of all base

stations in the vicinity of said detection area, whereby said mobile telephone is caused to transmit said response signal as a location registration signal.

The pseudo base station signal may be transmitted in a standard overhead channel of a wireless communications system.

The pseudo base station signal may include a pilot channel signal which is transmitted at a power level sufficient for a mobile telephone in said detection area to receive said pilot channel signal at greater strength than it receives pilot channel signals of all base stations in the vicinity of said detection area.

The method may further comprise the steps of generating a pseudo base station signal adapted according to zone information of neighbouring base stations, said pseudo base station signal containing zone information differing from the zone information of neighbouring base stations; transmitting said pseudo base station signal for reception by a mobile telephone within a detection area; receiving said pseudo base station signal and transmitting a location registration signal by any mobile telephone within the detection area; receiving the location registration signal from the mobile telephone; and generating an alarm when the location registration signal is received from said mobile telephone.

The step of generating a pseudo base station signal may comprise the steps of receiving an overhead channel

signal from a neighbouring base station; and obtaining information concerning the neighbouring base station by analysing the received overhead channel signal.

The step of receiving the overhead channel signal may include tuning to all possible overhead channels which may be used by base stations of a code division multiple access (CDMA) system.

The step of generating a pseudo base station signal may be performed when an object detection signal is received from an object detector indicating that an object has entered the detection area.

The pseudo base station signal is generated having system parameters different from system parameters transmitted in base station signals of neighbouring base stations.

The pseudo base station signal may be generated having time-related access parameters of an access channel in which said mobile telephone transmits said location registration signal, said time-related access parameters being adapted to reduce transmission-time for the location registration signal of said mobile telephone.

The pseudo base station signal may be generated sequentially in a plurality of overhead frequency channels of a code division multiple access (CDMA) system.

The step of receiving the location registration signal

may be performed by sequentially tuning to different frequency channels to enable reception of said location registration signal in any one of said different frequency channels.

The step of receiving the location registration signal may be performed by sequentially tuning only to access frequency channels being used in neighbouring base stations, to enable reception of said location registration signal in any one of said frequency channels.

The mobile telephone may be in an idle state.

Other objects, advantages and characteristics of the apparatus and method of the invention will become apparent upon reading the following description of certain embodiments of the invention, with reference to the accompanying drawings.

Brief Description of the Drawings

The following detailed description of certain embodiments of the present invention, given by way of examples only, will best be appreciated when read in conjunction with the accompanying drawings, wherein:

FIG. 1 illustrates a prior art system that generates an interference signal to prevent use of a mobile telephone;

FIG. 2 depicts a prior art system for detecting magnetic

objects;

FIG. 3 is a block diagram of an embodiment of an apparatus for detecting mobile telephones in accordance with a feature of the present invention;

FIG. 4 is a block diagram of an illustrative apparatus 200 for analysing neighbouring base stations in accordance with a feature of the present invention;

FIG. 5 depicts an embodiment of apparatus 300 for generating a pseudo base station signal in accordance with a feature of the present invention;

FIG. 6 is a block diagram of an embodiment of apparatus 400 for detecting a signal sent by a mobile telephone in accordance with a feature of the present invention;

FIG. 7 illustrates forward and reverse frequency channels of a code division multiple access (CDMA) system;

FIG. 8 illustrates forward and reverse frequency channels of personal communication services (PCS) system;

FIG. 9 is a flow chart of an exemplary method for detecting a mobile telephone according to a feature of the present invention; and

FIG. 10 shows waveforms illustrating a location registration signal of a mobile telephone.

Detailed Description of the Drawings

The present invention provides a method and apparatus for monitoring whether a mobile telephone in a specific detection area is in an idle state. An idle state is generally defined as a state in which the mobile telephone is powered-up in a standby mode, but is not engaged in active communication. In the idle state the mobile telephone is waiting for an incoming call to be detected through reception and analysis of control channel signals transmitted by the base station. As soon as control signals indicative of an incoming call are received by the mobile telephone, a call set-up process commences in which the mobile terminal and base station exchange messages. Thus, the present invention, by detecting the idle state condition, serves to prevent subsequent transmission of radio signals by the mobile telephone. On the other hand, if the mobile telephone is turned off, it is not registered with the local base station so the base station will not transmit any signals to the mobile telephone, and vice versa. The present invention is not designed to detect this condition since a mobile telephone which is turned off will not cause disturbance or danger by emitting noise or signal transmissions. Also, if the mobile telephone is turned on and communication is already being performed, typically a supervisor in the restricted area or building can detect such mobile telephone use without any specific means. It is not considered necessary in the present invention to detect mobile telephones which are actively communicating, either.

An apparatus according to the present invention makes it possible to detect a mobile telephone in idle state and to accordingly inform the mobile telephone user or a supervisor

An illustrative embodiment of the present invention will be described below in the context of a code division multiple access (CDMA) communication system. However, it is to be understood that the present invention is not so limited, and may be used in conjunction with other communication protocols such as a time division multiple access (TDMA) system.

In a code division multiple access (CDMA) system, the reverse channel, which is the communication link from the mobile telephone to the base station, includes an access channel and a traffic channel. The access channel is a channel which enables the mobile telephone to obtain information to communicate with the base station. The traffic channel is used to send and receive voice data to/from the base station after communication is established through the access channel. The present invention detects a mobile telephone in the idle state by detecting the initial signal that the mobile telephone transmits through the access channel to a base station. This initial signal in the access channel is typically a signal requesting registration with a new base station, as will be explained further below.

The mobile telephone in idle state receives system

parameters from the wirelessly connected base station when the mobile telephone's power is initially turned on. The connected base station is assumed to be the base station that primarily serves the cell in which the mobile telephone is located. Base stations have overlapping coverage areas, so it is possible for more than one different base station to service a mobile telephone at a given location.

The system parameters include a frequency to be tuned to by the mobile telephone, pseudo-random noise (PN) code offset to identify each base station, etc. The mobile telephone, having received the system parameters, maintains operation in the idle state, continuing to receive signals from the base station. The mobile telephone in idle state receives a pilot signal from the base station, where the pilot signal contains the base station's own PN code offset information.

At this time, if a second pilot signal, having different PN offset information but using the same frequency, is received from a neighbouring base station with higher signal strength than the pilot signal of the currently connected base station, the mobile telephone tunes to the neighbouring base station. The switch-over of a mobile telephone in idle state between base stations is called idle handoff. The mobile telephone performing the idle handoff does not send any signal to the base station - it just receives parameters from the new base station and stores them.

The mobile telephone moving between base stations, if necessary, registers its location to a mobile switching centre through one of the base stations such that only that one base station or its neighbouring base stations will be called when the mobile switching centre calls the mobile telephone. That is, location registration is performed for the purpose of facilitating call delivery to the mobile telephone in idle state. Signals for location registration are transmitted to the base station only by mobile telephones in idle state.

In accordance with the present invention, a detection apparatus is provided which determines if a mobile telephone in the idle state is present, by detecting whether a location registration signal is transmitted from a mobile telephone. The detection apparatus sends a pseudo (or "dummy") base station signal to any mobile telephone in the detection area, to prompt the mobile telephone to transmit a location registration signal when the mobile telephone passes through a detection area.

The general process for performing location registration by a mobile telephone operating in a CDMA system is as follows. A parameter-based location registration is performed when the system parameters received from a new base station differ from the system parameters already set up with the mobile telephone. An order-based location registration is performed when a location registration is ordered for a specific mobile telephone on the instructions of the base station. A timer-based location registration is performed whenever a specific

time passes after performing the last location registration.

In general, the location registration is performed every two hours, so the probability for the mobile telephone to send the timer based location registration signal within a particular one-second time frame is 1/7200. This is insufficient, as a mobile telephone in idle state may only spend about 1 second in the detection area, if the detection area is an entranceway. In an embodiment of the invention, the pseudo base station signal is generated having time-related access parameters of an access channel in which said mobile telephone transmits said location registration signal. The time-related access parameters are preferably adapted to reduce transmission-time for the location registration signal of said mobile telephone.

A zone-based location registration is performed when the mobile telephone enters a new zone. A cellular system divides the overall service area into several zones and allocates a zone number, characteristic for each zone. The base stations located in a specific zone transmit a common zone number associated with that zone through the paging channel.

An embodiment of the invention will now be described, which is implemented in a zone-based location registration system to enable the mobile telephone to be effectively tricked into transmitting a location registration signal when it enters a specific detection

area. A detection apparatus according to a feature of the present invention includes a signal generating unit that transmits a pseudo base station signal including a new zone number. The mobile telephone in idle state, when in the detection area, receives the pseudo base station signal and recognises that a new zone has been entered. The mobile telephone responds by transmitting a location registration signal through the access channel for the purpose of registering in the new zone. The location registration signal transmitted by the mobile telephone is detected by the detection apparatus, and an audible alarm is sounded, or a visual alarm signal is shown, or other alarm means are activated, to indicate that a mobile telephone is present and is not turned off, in the restricted area.

Each zone in a code division multiple access (CDMA) system is classified according to the zone number, a system identifier (SID) to identify the system providers, and a network identifier (NID) to identify the networks of the mobile switching centre. The mobile telephone receives values for these parameters from the base station and compares them to values currently stored. If any of the new values are different from the stored ones, the mobile telephone determines that it has entered a new area, whereupon a location registration to a base station in the new area is performed by the mobile telephone.

In light of the above, an illustrative example of a detection apparatus according to a feature of the present invention is equipped with circuitry for receiving and

analysing information transmitted from neighbouring base stations. Such information includes each neighbouring base station's zone number, system identifier and network identifier, the transmit frequency status, the pilot signal strength, the PN code offset, etc. The detecting apparatus then selects area information different from that of the neighbouring base stations, to ensure that a mobile telephone entering the restricted area receives parameters different from those which are currently stored.

FIG. 3 is a block diagram of an embodiment of an apparatus, 100, for detecting a mobile telephone in idle state according to an embodiment of the present invention. A GPS receiver 110 receives time information from satellites and generates a system reference clock. An apparatus 200 for analysing neighbouring base stations receives overhead channel signals from neighbouring base stations through antenna 210, and analyses the same to generate neighbouring base station information. This information is stored in a memory 260. A signal-generating unit 300 generates a pseudo base station signal based on the system reference clock and the neighbouring base station information. The pseudo base station signal is transmitted to any mobile telephone in the detection area via antenna 350. A mobile telephone MS in idle state responds to the pseudo base station signal by transmitting a location registration signal, which is detected by a detecting unit 400 via antenna 410. An alarm-generating unit 500 generates an alarm when detecting unit 400 detects a location registration signal

transmitted by the mobile telephone MS in response to the pseudo base station signal. A power supply 600 supplies operating power to the various components of apparatus 100.

Antennae 350 and 410 are preferably situated in a location of the restricted area such that isolated transmission and reception of signals to and from a particular mobile telephone in the restricted area can be carried out. For instance, antennae 350 and 410 may be located on the perimeter of an entranceway to achieve transmission/reception of signals to/from mobile telephones carried by persons as they pass through the entranceway. To reduce the occurrences of unintentional communication with mobile telephones outside the restricted area, and the possibility of interference with other electronic equipment, transmitting antenna 350 is preferably designed with a narrow beam that points to the restricted area. Optionally, RF emissions are minimised to reduce such interference by deploying an object detector 305, such as that illustrated in Fig. 2, in the entranceway or the like to detect the presence of a mobile telephone on a person, prior to any radiation by antenna 350. Whenever an object is detected, object detector 305 sends a corresponding signal to signal-generating unit 300, which responds by transmitting the pseudo base station signal through antenna 350. Object detector 305 may alternatively operate, for example, by recognising a change in weight or light in the detection area, to react to any passing person or object, not only in response to the presence of magnetic materials.

Referring now to FIG. 4, a block diagram of an embodiment of the apparatus 200 for analysing neighbouring base stations is shown. Receiving antenna 210 receives RF signals through the overhead channel(s) from neighbouring base stations. A first receiving filter 220 excludes out-of-band signals from the received RF signals. First frequency down-converter 230 converts the filtered signal output by filter 220 to a baseband signal. A forward demodulator 240 demodulates the baseband signal by means of a de-spreading operation. An overhead channel analyser 250 analyses the overhead channel information of the demodulated signal so as to extract the neighbouring base station information, for storage in memory 260, for use by signal generating unit 300.

FIG. 5 is an embodiment of the signal-generating unit 300 which generates the pseudo base station signal in accordance with a feature of the invention. The unit 300 includes a forward modulator 310 for generating an overhead channel signal using the reference clock received from GPS receiver 100 and the neighbouring base station information retrieved from memory 260. A frequency up-converter 320 converts the overhead channel signal to an RF signal at an appropriate frequency used by the CDMA system. The up-converted pseudo base station signal is amplified by transmit power amplifier 330, filtered by transmitting filter 340 and radiated into the detection area by antenna 350.

With reference now to FIG. 6, an embodiment of detecting

unit 400 according to a feature of the invention, is illustrated in a block diagram. A second receiving antenna 410 receives RF signals in the access channel from a mobile telephone in idle state. The received RF is filtered by second receiving filter 420 and down-converted to baseband by a second frequency down-converter 430. Reverse demodulator 440 de-spreads the baseband signal and activates an alarm-generating unit 500 if the information contained within the baseband signal corresponds to a location registration signal. Processing circuitry for making this determination resides either within the reverse demodulator 440 or within the alarm unit 500.

In order to detect signals from mobile telephones and base stations transmitted at all possible frequencies in the CDMA system, detection apparatus 100 searches all usable frequencies in the CDMA system. At present, there are two frequency bands commonly allocated for CDMA wireless communications: the cellular system 800 MHz band and the personal communication service (PCS) system 1800 MHz band. As illustrated in FIG. 7, in the cellular system the reverse channel from the mobile telephone to the base station uses a 25 MHz band between 824 MHz and 849 MHz and the forward channel from the base station to the mobile telephone uses a 25 MHz band between 869 MHz and 894 MHz. As illustrated in FIG. 8, in the PCS system the reverse channel uses a 30 MHz band between 1750 MHz and 1780 MHz and the forward channel uses a 30 MHz band between 1840 MHz and 1870 MHz.

The frequency separation between the forward and reverse channels is 45 MHz in the cellular system and 90 MHz in the PCS system. In both the cellular and PCS systems, CDMA frequency bands with 1.25 MHz bandwidth may be used for each frequency channel. For example, if the transmit frequency of the base station is F1, the transmit frequency of the mobile telephone to respond to the F1 signals should be (F1 plus 45) MHz in the cellular system or (F1 plus 90) MHz in the PCS system. Therefore, up-converter 320, down-converters 230, 430, transmitting filter 340, and receiving filters 220, 420 operate in 1.25 MHz intervals within a 55 MHz range (which is derived from 25 MHz plus 30 MHz forward and reverse bandwidths as discussed in the preceding paragraph). For instance, receiving filters 220 and 420 are each bandpass filters with an electronically controlled passband (1.25MHz wide), the centre frequency of which is sequentially translated in steps of 1.25MHz to sequentially capture the signals of adjacent channels. The other components likewise operate in 1.25MHz intervals to obtain complete coverage over the whole CDMA band(s). Transmitting filter 340 and receiving filter 420 operate with 45 MHz (or 90 MHz) separation; likewise, up-converter 320 and down-converter 430 operate with 45 MHz (or 90 MHz) separation.

Referring to FIG. 9 (to be read in conjunction with FIGS. 3-8), a flowchart of an illustrative method for detecting a mobile telephone in the idle state according to a feature of the present invention is presented. The method begins in step s110, in which information is received by

antenna 210 in overhead channels from neighbouring base stations in the general vicinity of the detection apparatus. This information, which is received and analysed by apparatus 200 of FIG. 3, includes zone information, PN codes, etc. of the neighbouring base stations. Apparatus 200 also analyses the signal strengths of the respective pilot signals and stores the signal strength information in memory 260. The signal strength information is used to ensure that the pseudo base station signal to be transmitted will reach the mobile telephone in the detection area with more power than the highest power pilot signal of the neighbouring base stations.

The signal received at the receiving antenna 210 is transformed into a baseband signal through the first receiving filter 220 and the first frequency down-converter 230. The first receiving filter 220 searches the frequency bandwidth of 55 MHz by sequentially translating its passband in 1.25MHz intervals, thereby capturing signals from all neighbouring base stations. The baseband signal received on each 1.25MHz frequency channel is de-spread by the forward demodulator 240. Overhead channel analyser 250 decodes the de-spread signal to analyse the status of all neighbouring base stations such as the strength of the pilot signal for each frequency channel, the zone number, system identifier and network identifier, etc. The analysis results for each frequency channel are stored in memory 260 and used to generate the pseudo base station signal. The overhead channel signal being received from a given

neighbouring base station remains generally unchanged as long as the system configuration stays the same. Therefore, it is unnecessary for overhead channel analyser 250 to operate at all times. Hence, to save operating power, apparatus 200 can be designed to demodulate signals, analyse overhead channels, etc., on a periodic basis rather than continually.

With continuing reference to FIG. 9, in step s120, signal generating unit 300 utilises the zone information of the neighbouring base stations stored in memory 260 to generate a pseudo base station signal that contains new zone information. The pseudo base station signal is an overhead channel signal generated by forward modulator 310, and includes a system identifier (SID), network identifier (NID), new zone number and new PN offset not used by any of the neighbouring base stations, etc. Tables 1 and 2 below represent a message format that is typically used for transmission in the sync channel and the paging channel (of the pseudo base station signal as well as for neighbouring base station signals).

The forward modulator 310 generates the paging/sync channel signals for all paging frequency channels being used by the neighbouring base stations.

Field	Length (bits)
Message type '00000001'	8
System identifier (SID)	15
Network identifier (NID)	16
PN code offset (PILOT_PN)	9
System time (SYS_TIME)	36

Table 1. Sync Channel Message

Field	Length (bits)
Message type '00000001'	8
PN code offset (PILOT_PN)	9
System identifier (SID)	15
Network identifier (NID)	16
Registration zone (REG_ZONE)	12
Zone timer (ZONE_TIMER)	3

Table 2. System Parameter message of Paging Channel

The pseudo base station signal is transmitted to a mobile telephone in the detection area in step s130. Preferably, by employing object detector 305 as discussed above in the detection area vicinity, the pseudo base station signal is transmitted only upon the detection of an object. In this manner, the total RF emissions are reduced and electrical power is saved as well. If an object enters the detection area, object detector 305 sends a specific signal to signal generating unit 300, whereupon forward modulator 310 generates the pseudo base station signal. The modulated signal is up-converted, amplified and transmitted at an appropriate power level,

e.g. a few milliwatts, to the mobile telephone via antenna 350. At this time, the pseudo base station signal is generated and transmitted on all overhead channel frequencies used by the neighbouring base stations. Thus, the forward modulator 310, up-converter 320, power amplifier 330, and filter 140 all operate at successive intervals of 1.25MHz so as to generate and transmit the pseudo base station signal at all possible overhead channel frequencies in a short time interval. This ensures that the mobile telephone, which is typically tuned to only one of the 1.25MHz channels, will properly receive the pseudo base station signal.

In step s140, the mobile telephone receives the pseudo base station signal and recognises that it contains a new pilot signal with a higher power level than the highest power pilot signal currently being received. As a result, the mobile telephone is tricked into beginning the location registration process to register with the new (pseudo) base station by tuning to the sync channel using the detected pilot signal. The mobile telephone obtains timing information of the pseudo base station from the sync channel and searches the paging channel using the timing information to extract the desired base station information. It analyses the area information included in the pseudo base station signal, in particular, the zone number, system identifier and network identifier, and compares those with the currently stored area information (from the last neighbouring base station that the mobile telephone registered with). Since the received area information is different from the stored area

information, the mobile telephone tunes to the pilot signal within the pseudo base station signal and then transmits a location registration signal to detection apparatus 100 to demand a location registration. The detection apparatus receives the location registration signal at step s150, and activates alarm unit 500 to indicate that a mobile telephone in idle state has been detected.

FIG. 10 illustrates a location registration signal transmitted by a mobile telephone. To achieve location registration, the mobile telephone transmits an access probe sequence including a plurality of probe signals repeatedly. Waveform (A) of FIG. 10 illustrates an access probe sequence in which probe sequence signals are repeatedly transmitted at time intervals T1. A maximum of 15 probe sequences are transmitted. As illustrated by waveform (B) of Fig. 10, each probe sequence contains up to sixteen access probes which are sequentially transmitted at time intervals T2, with each successive probe signal having a higher power level than the previous one by P1 power units. As illustrated by diagram (C) of Fig. 10, each access probe signal includes preamble and message portions each having a number of frames, e.g. 4 to 26 frames, each 20ms in duration.

The mobile telephone transmitting the above location registration signal is provided with various access parameters such as T1, T2, the number of frames in the access probe signal, the power level increment P1, etc. These access parameters are transmitted from the base

station through the paging channel, and are determinative of the characteristics of the location registration signal to be transmitted. If general access parameters are used, it takes about one or two seconds for the base station to recognise the location registration signal transmitted from the mobile telephone, assuming the location registration signal frequency band is known by the base station.

Returning to FIG. 9, in step s150, detecting unit 400 searches for and ultimately receives the location registration signal from the mobile telephone via antenna 410. That is, the received signal from the antenna is applied to reverse demodulator 440 through the receiving filter 420 and down-converter 430. Reverse demodulator 440 de-spreads and demodulates the signal from down-converter 430 and then analyses the modulated signal to determine if a location registration signal is present. When this signal is present, an alarm is generated by the alarm unit 500 in step s160 to alert the person carrying the mobile telephone or a supervisor that a mobile telephone in idle state is present and should be turned off.

The signal searching operation of step s150 will now be considered in more detail. Since the combined usable frequency band in the reverse channels of the cellular system and PCS systems is 55 MHz (i.e., 25MHz plus 30MHz, respectively), detection unit 400 may be designed to perform a search for a location registration signal within each 1.25MHz frequency channel of the 55MHz band.

As a result, assuming a 1.5 second search in each frequency band, it would take about 66 seconds to search all the frequency channels (where (55/1.25) x 1.5 seconds = 66 seconds). The 66 second search time thus represents the maximum time needed to detect a location registration signal, assuming that the mobile telephone may possibly be transmitting in the last frequency channel searched. However, 66 seconds is too much time to be allocated for detecting a mobile telephone in most practical situations. One way to shorten the detection time is for signal generating unit 300 to change the access parameters.

Table. 3 below represents a format of an access parameter message transmitted by a base station through the paging channel.

Field	Length (bits)
Message type '00000010'	8
PILOT_PN	9
ACC_MSG_SEQ	6
ACC_CHAN	5
MAX_CAP_SZ	3
PAM_SZ	4
ACC_TMO	4
PROBE_BKOFF	4
BKOFF	4

Table 3. Access Parameter Message Format

To shorten the time required to detect the transmission of a location registration signal by the mobile telephone, the access parameters can be changed. In this case, the signal-generating unit 300 transmits the paging channel signal of the pseudo base station signal with new access parameters. In particular, signal-generating unit 300 adjusts the time variables T1 and T2 to shorten the time required to recognise the location registration signal of the mobile telephone.

In general, CDMA service providers are allocated forward and reverse channel bandwidths as wide as 10 MHz, to enable use of eight frequency channels in total. Practically, however, the service providers use only one or three frequency channels. Therefore, if only the one or three frequency channels in current use are searched when signal-generating unit 300 generates a pseudo base station signal and detecting unit 400 detects the location registration signal, the search time can be shortened to 3/8 or 1/8 of the time required in the case in which all available frequency bands are searched.

Also, as the probability is high that the mobile telephone in idle state is already tuned to one of the neighbouring base stations, detection apparatus 100 can be designed to operate, at any given time, only at the frequency or frequencies being used in the neighbouring base station(s), rather than at all forward channel frequencies. In this manner, the search time required by detecting unit 100 to detect the location registration signal from the mobile telephone can be shortened

dramatically, since the search need only be performed at one, or a small number of frequency channels. Additionally, if detection apparatuses for the cellular PCS systems are configured in parallel, i.e., with one detection unit operating at the cellular band and the other operating independently at the PCS band, the search time can be further shortened.

From the foregoing, it should be readily appreciated that embodiments of the present invention render it possible to call a person's attention to the idle state use of his/her mobile telephone within a specific detection area by detecting if the mobile telephone in idle state passes through the specific detection area. Consequently, it is possible to prevent public injury or inconvenience, and the possibility of causing electronic equipment to erroneously operate, by restricting mobile telephone use in a specific area. In addition, embodiments of the present invention make it possible to more precisely detect a mobile telephone in idle state by recognising a location registration signal of the mobile telephone as soon as possible.

CLAIMS:

1. An apparatus for detecting a mobile telephone comprising:

- a signal generating unit for generating a pseudo base station signal;
- a detecting unit adapted to detect a response signal transmitted by a mobile telephone in response to the pseudo base station signal; and
- an alarm generating unit for generating an alarm when said detecting unit detects said response signal.

2. The apparatus as set forth in claim 1, wherein said pseudo base station signal includes zone information differing from zone information used in base stations in the vicinity of the apparatus.

3. The apparatus as set forth in claim 2, wherein said zone information includes one or more of: pseudo-random noise (PN) code offset; zone number; a system identifier (SID); and a network identifier (NID).

4. The apparatus as set forth in any preceding claim, further including circuitry for analysing signals received from neighbouring base stations, to extract neighbouring base station information therefrom, wherein said signal generating unit generates said pseudo base station signal adapted according to said neighbouring base station information.

5. The apparatus as set forth in claim 4, wherein said

circuitry for analysing signals received from neighbouring base stations comprises:

- a first receiving antenna for receiving radio frequency (RF) signals through an overhead channel from the neighbouring base stations;
- a first receiving filter to filter said received signals;
- a first frequency down-converter to convert the filtered signal to a baseband signal;
- a forward demodulator to demodulate the baseband signal; and
- an overhead channel analyser to analyse the demodulated signal and generate said neighbouring base station information.

6. The apparatus as set forth in claim 4 or claim 5, wherein said extracted neighbouring base station information includes one or more of: transmit frequency status; pilot signal strength; and pseudo-random noise (PN) code offset.

7. The apparatus as set forth in any preceding claim, wherein said signal-generating unit comprises:

- a forward modulator for generating an overhead channel signal;
- an up-converter for converting the overhead channel signal to an RF signal in a frequency band of a code division multiple access (CDMA) system;
- a transmit power amplifier for amplifying the RF signal;
- a transmitting filter for filtering the amplified

signal; and

- a transmitting antenna for transmitting the filtered signal as said pseudo base station signal.

8. An apparatus as set forth in any preceding claim, further comprising a global positioning system (GPS) receiver for receiving time information from a satellite and generating therefrom a system reference clock.

9. The apparatus as set forth in claim 8, wherein said signal-generating unit generates said pseudo base station signal using the system reference clock.

10. The apparatus as set forth in claim 8 or claim 9 wherein the forward modulator generates the overhead channel signal using the system reference clock.

11. The apparatus as set forth in any of claims 7-10, wherein said transmit power amplifier amplifies the RF signal to a power level of several milliwatts, so as to prevent interference with electronic equipment outside a specific detection area.

12. The apparatus as set forth in any of claims 7-11, wherein said transmitting antenna transmits an overall forward frequency band of said CDMA system.

13. The apparatus as set forth in any of claims 7-12, wherein said transmitting antenna transmits a narrow beamwidth directed towards a specific detection area.

14. The apparatus as set forth in any preceding claim, wherein said apparatus transmits said pseudo base station signal in response to a signal from an object detector indicating that an object is within a specific detection area.

15. The apparatus as set forth in any preceding claim, wherein said detecting unit comprises:

- a receiving antenna for receiving radio frequency (RF) signals from a mobile telephone;
- a receiving filter for filtering said received RF signals;
- a down-converter for converting the filtered signal to a baseband signal; and
- a reverse demodulator for de-spreading and demodulating the baseband signal and forwarding an alarm signal to the alarm-generating unit when said response signal of the mobile telephone is detected within said demodulated signal.

16. The apparatus as set forth in claim 15, wherein the frequency separation, at a given time, between a passband of said receiving filter and a passband of a transmitting filter of said signal generating unit that filters said pseudo base station signal, is selected from the group consisting of 45MHz and 90MHz.

17. The apparatus as set forth in claim 16, wherein said receiving filter and the transmitting filter each have a passband of 1.25 MHz.

18. The apparatus as set forth in any preceding claim, wherein said signal-generating unit comprises:

- circuitry for generating said pseudo base station signal at frequencies, and with a protocol, of a code division multiple access (CDMA) cellular system; and/or
- circuitry for generating said pseudo base station signal at frequencies, and with a protocol of, a CDMA personal communication service (PCS) system.

19. The apparatus as set forth in any preceding claim wherein said detecting unit comprises:

- circuitry for detecting a signal that a mobile telephone transmits at frequencies, and with a protocol, of a CDMA cellular system; and/or
- circuitry for detecting a signal that said mobile telephone transmits at frequencies, and with a protocol, of a CDMA personal communication service (PCS) system.

20. The apparatus as set forth in any preceding claim, wherein said detection unit is located in an entranceway.

21. An apparatus as set forth in any preceding claim, wherein said pseudo base station signal is adapted to cause a mobile telephone to transmit location registration signals; and wherein the detecting unit is adapted to detect said location registration signals.

22. A method for detecting a mobile telephone, said method comprising the steps of:

- transmitting a pseudo base station signal within a detection area, said pseudo base station signal being

adapted to cause a mobile telephone in said detection area to transmit a response signal;

- receiving a response signal from a mobile telephone; and
- generating an alarm in response to the reception of the response signal from the mobile telephone.

23. The method as set forth in claim 22, wherein said pseudo base station signal contains zone information differing from zone information of all base stations in the vicinity of said detection area, whereby said mobile telephone is caused to transmit said response signal as a location registration signal.

24. The method of claim 22 or claim 23, wherein said pseudo base station signal is transmitted in a standard overhead channel of a wireless communications system.

25. The method of any of claims 22-24, wherein said pseudo base station signal includes a pilot channel signal which is transmitted at a power level sufficient for a mobile telephone in said detection area to receive said pilot channel signal at greater strength than it receives pilot channel signals of all base stations in the vicinity of said detection area.

26. A method for detecting a mobile telephone in idle state, according to any of claims 24-25, said method further comprising the steps of:

- generating a pseudo base station signal adapted according to zone information of neighbouring base

stations, said pseudo base station signal containing zone information differing from the zone information of neighbouring base stations;

- transmitting said pseudo base station signal for reception by a mobile telephone within a detection area;
- receiving said pseudo base station signal and transmitting a location registration signal by any mobile telephone within the detection area;
- receiving the location registration signal from the mobile telephone; and
- generating an alarm when the location registration signal is received from said mobile telephone.

27. The method as set forth in claim 26, wherein said step of generating a pseudo base station signal comprises the steps of:

- receiving an overhead channel signal from a neighbouring base station; and
- obtaining information concerning the neighbouring base station by analysing the received overhead channel signal.

28. The method as set forth in claim 27, wherein the step of receiving the overhead channel signal includes tuning to all possible overhead channels which may be used by base stations of a code division multiple access (CDMA) system.

29. The method as set forth in any of claims 22-28, wherein the step of generating a pseudo base station

signal is performed when an object detection signal is received from an object detector indicating that an object has entered the detection area.

30. The method as set forth in any of claims 26-29, wherein said pseudo base station signal is generated having system parameters different from system parameters transmitted in base station signals of neighbouring base stations.

31. The method as set forth in any of claims 26-30, wherein said pseudo base station signal is generated having time-related access parameters of an access channel in which said mobile telephone transmits said location registration signal, said time-related access parameters being adapted to reduce transmission-time for the location registration signal of said mobile telephone.

32. The method as set forth in any of claims 22-31, wherein said pseudo base station signal is generated sequentially in a plurality of overhead frequency channels of a code division multiple access (CDMA) system.

33. The method as set forth in any of claims 26-32, wherein the step of receiving the location registration signal is performed by sequentially tuning to different frequency channels to enable reception of said location registration signal in any one of said different frequency channels.

34. The method as set forth in any of claims 26-33, wherein the step of receiving the location registration signal is performed by sequentially tuning only to access frequency channels being used in neighbouring base stations, to enable reception of said location registration signal in any one of said frequency channels.

35. A method or apparatus according to any preceding claim wherein the mobile telephone is in an idle state.

36. An apparatus for detecting a mobile telephone substantially as described with reference to and/or as shown in Figs. 3-10 of the accompanying drawings.

37. A method for detecting a mobile telephone substantially as described with reference to and/or as shown in Figs. 3-10 of the accompanying drawings.

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H4L (LDLS, LDLX, LFM)

Int Cl (Ed.6): H04Q 7/34, 7/38

Other: Online: WPI, EPODOC, PAJ

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 2317304 A	(NEC)	
A	US 5548800	(OLDS)	

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